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(58) Field of search
G3U
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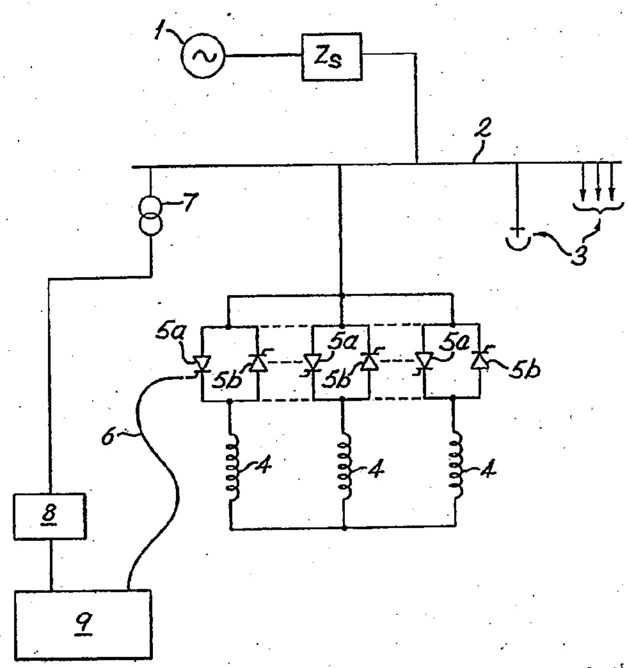
(54) **Alternating curent power supplies**

(57) An a.c. supply is maintained at constant voltage by switching selected linear reactors 4 in shunt across the supply 1, 2 for an integral number of half-cycles by means of a microprocessor controller 9 responsive to an analog/digital convertor 8 which samples the supply voltage. Light-operated thyristors 5*a*, 5*b* are switched at current zero crossings, ie. at the peak of the supply voltage. A plurality of windings (13), (17), (20), (21), (Figure 3), may be provided on a common core, the windings (13, (17), and (20) each having associated series and shunt thyristors; a plurality of such tyristor-reactor networks may be connected in parallel in each phase of the supply.



compensation

Fig. 1

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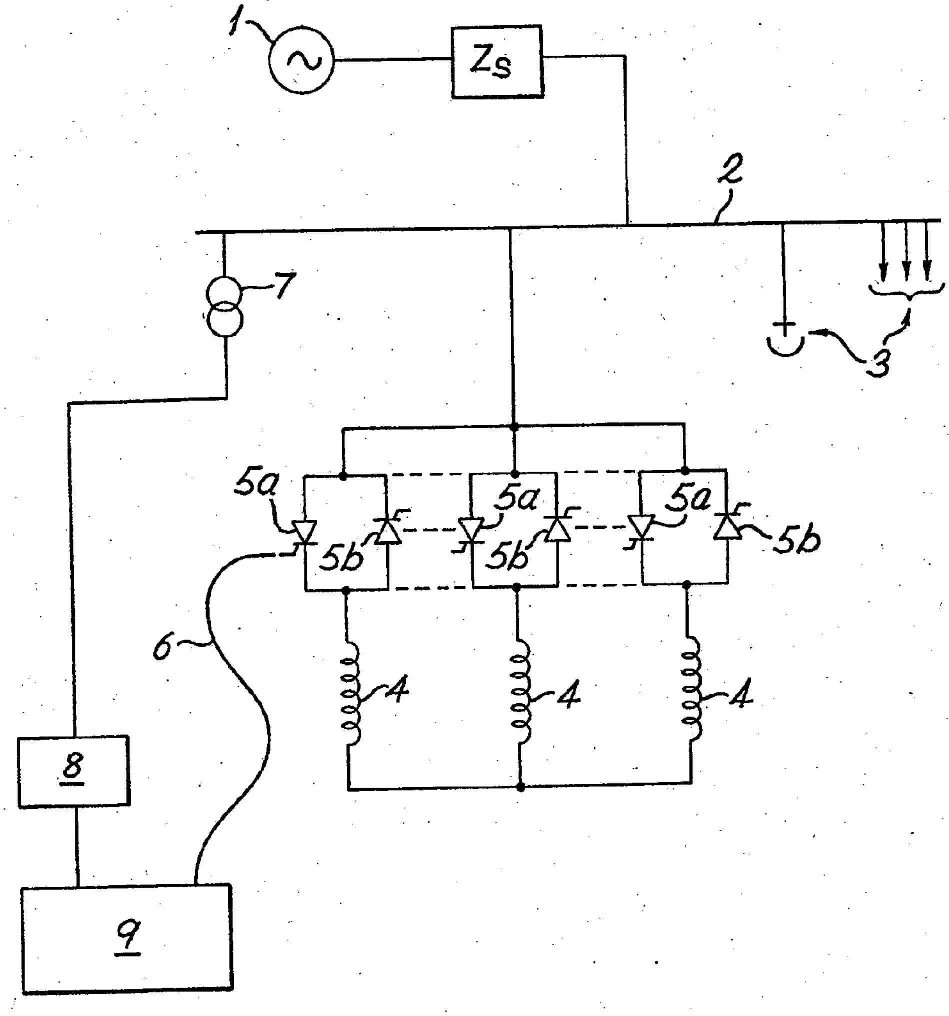

Fig. 1

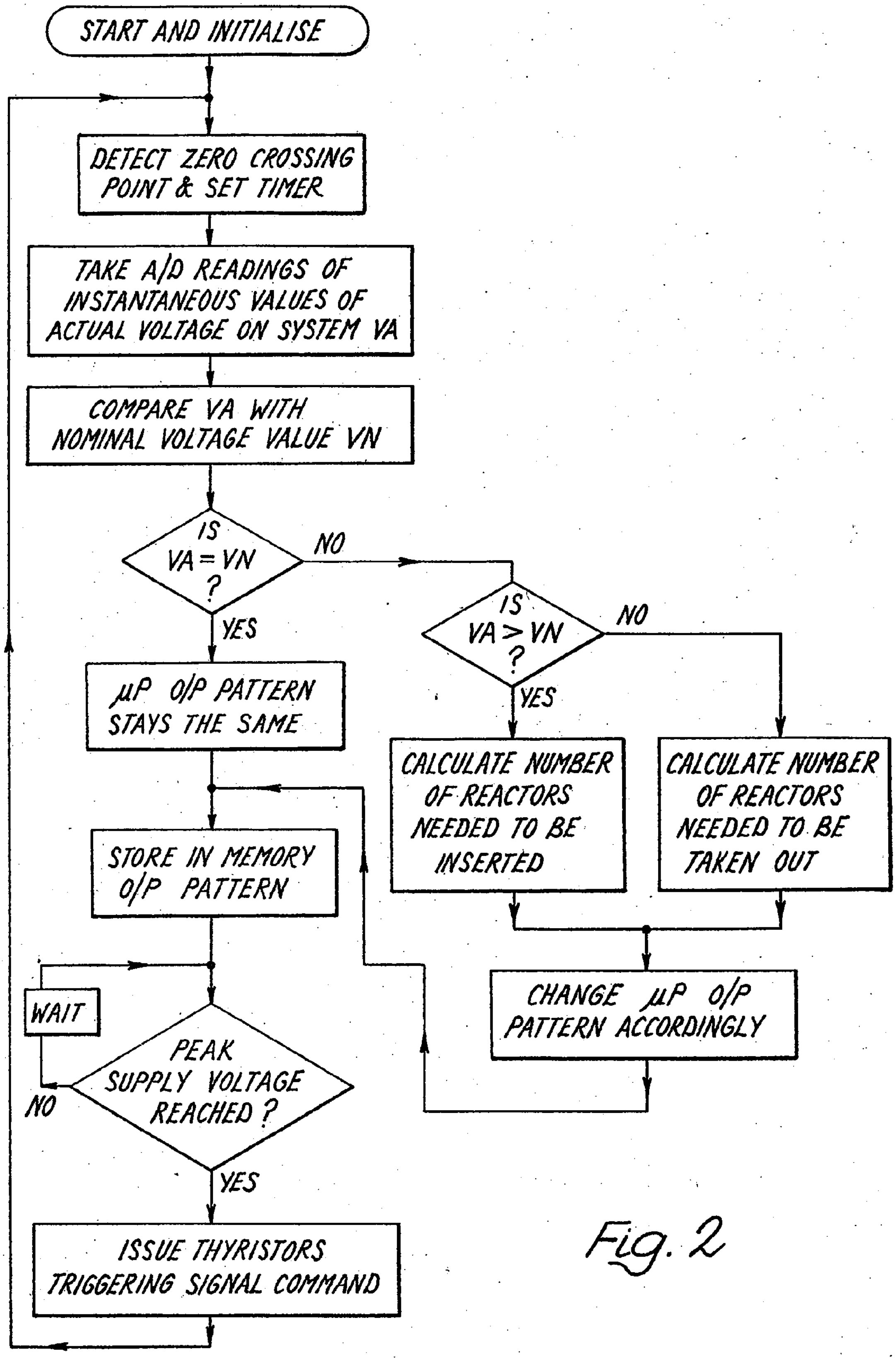
START AND INITIALISE
DETECT ZERO CROSSING POINT & SET TIMER
TAKE A/D READINGS OF INSTANTANEOUS VALUES OF ACTUAL VOLTAGE ON SYSTEM VA
COMPARE VA WITH NOMINAL VOLTAGE VALUE VN
IS VA = VN ?
NO
YES
IS VA > VN ?
NO
YES
μP O/P PATTERN STAYS THE SAME
CALCULATE NUMBER OF REACTORS NEEDED TO BE INSERTED
CALCULATE NUMBER OF REACTORS NEEDED TO BE TAKEN OUT
STORE IN MEMORY O/P PATTERN
CHANGE μP O/P PATTERN ACCORDINGLY
WAIT
PEAK SUPPLY VOLTAGE REACHED ?
NO
YES
ISSUE THYRISTORS TRIGGERING SIGNAL COMMAND

Fig. 2

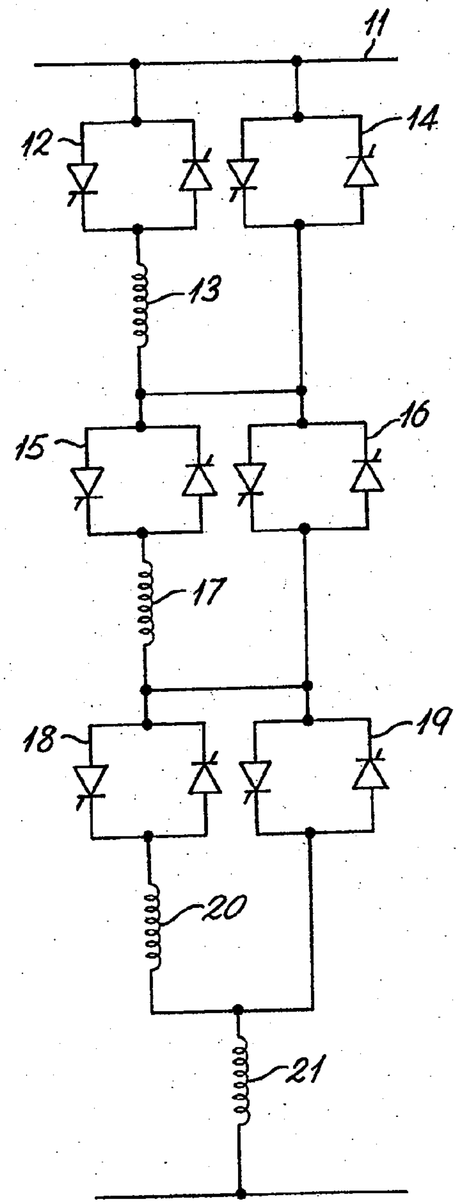

Fig. 3

SPECIFICATION

Alternating current power supplies

This invention relates to controllers for alternating current power supplies for a variable load and, in particular, to power supplies incorporating linear shunt reactors.

Saturable reactors, or transductors, are commonly employed to stabilise alternating current power supplies. In one such arrangement, control is effected by means of linear shunt reactors, which are either air-cored, or have air gaps in an iron core in order to minimise saturation effects. Such reactors have to be disconnected during periods of heavy load in order to avoid excessive voltage drop. In such cases, switching is carried out manually according to a predicted loading schedule. With some power supplies a single shunt reactor is used to regulate the absorbed reactive power using a phase-controlled thyristor switch, but this method has the disadvantage of producing harmonic currents.

In British Patent 1,431,867, a phase-controlled switching device is used to control a transductor. It has been found, however, that it is advantageous to employ switching devices which are triggered at or near the zero crossing point of the current in the reactors, in order to reduce production of harmonics.

According to the present invention there is provided a controller for an alternating current power supply for a variable load comprising voltage sampling means connectable to a power supply to sample the voltage applied to said load, at least one linear reactor connectable to said power supply and controller means connected between said reactor and said sampling means, said controller means being adapted to connect said reactor to said power supply for a substantially integral number of half-cycles of the supply voltage, shunt capacitors also being connected between said controller means and said sampling means.

The invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows schematically one embodiment of a power supply in accordance with the invention;

Figure 2 is a flow chart depicting the operating algorithm of the power supply of Figure 1; and

Figure 3 is the circuit diagram of an alternative embodiment of the invention.

Referring now to the drawings, a power supply 1 of source impedance Z, is connected to a system busbar 2, connected to a plurality of loads 3. A plurality of linear reactors 4 are connected in shunt with the system busbar. In series with each reactor is a pair of thyristors 5*a*, 5*b* connected in antiparallel. The thyristors are light-activated to provide electrical isolation, and ensure freedom from electromagnetic interference without the requirement for pulse transformers. Triggering pulses are provided by a gallium arsenide infra-red radiation emitting diode, which is coupled to the thyristors by means of fibre optic links 6.

An instrument voltage transformer 7 is connected to the systems busbar and its secondary winding feeds an analogue/digital converter 8. The A/D converter is of the tracking bipolar type with a fast speed of conversion and provides a digital output corresponding to an instantaneous value of the system voltage. Sampling occurs at one microsecond intervals throughout the positive and negative half-cycles of the system voltage. Output signals from the A/D converter are fed into a microprocessor controller 9 which may, typically comprise a 6502 processor with its associated memory and a 6522 VIA driving the optical link to the control thyristors.

The thyristors are triggered at the instant of zero crossing of the current to minimise reactor inrush currents. They are switched at the peak of the supply voltage.

A flow-chart illustrating the microprocessor control algorithm is shown in Figure 2. Startup is controlled by a bootstrap program held in ROM. At the voltage zero crossing point the A/D converter provides a trigger signal which sets a timer. Sampled voltages are compared with a reference voltage and on error the change in number of reactors required in circuit to maintain a substantially constant network voltage is calculated, the revised pattern is stored in memory and, at the appropriate instant, the thyristor trigger command is issued.

The reactors may have equal inductances to provide equal steps, although greater versatility and economy may be achieved by employing an asymmetric arrangement using the microprocessor to calculate which combination will provide the optimum compensation.

In an alternative embodiment (shown for one phase in Figure 3) a single reactor has a plurality of windings 13, 17, 20, 21 on a single core. The windings are interconnected by means of anti-parallel thyristor switches 12, 14, 15, 16, 18, 19, the entire combination being connected to the point 11 of common coupling with the power supply line.

A plurality of such thyristor-reactor networks may be connected in parallel in each phase to permit any required combinations of anti-parallel thyristors to be triggered independently, thus providing any desired level of compensation. For each component network, the compensation per phase is inversely proportional to the square of the combined number of turns connected in series. A suitable percentage of the total number of turns is 36% in winding 13, 28% in 17, 25% in 20 and 11% in 21. With this arrangement winding 21 will provide an effective short circuit if incorrect triggering occurs. The winding 21 is preferably located at such a position on the core that a relatively high leakage reactance will be exhibited if one of the other windings is short-circuited. If anti-parallel thyristors 12, 15 and 18 are triggered then the maximum number of turns is placed in series activating a minimum relative compensation factor of 1.0. The greatest design rating is for windings 20, 21 in series which gives 36% of the maximum number of turns and a relative compensation factor of 7.72 $(1/0.36)^2$. This requires that anti-parallel thyristors 14, 15, 18 should be triggered.

If thyristor parts 12, 16, 18 are triggered the relative compensation factor will be 1.93.

In three-phase operation a combination of independent single phase controllers may be used, connected in star or delta format as preferred. The combination is capable of stabilising the system voltage and reducing voltage imbalance between the three-phases at the point of common coupling even when the load is independently fluctuating on each phase at the point of common coupling, even when the load is independently fluctuating on each phase.

By maintaining a constant voltage at the end of a transmission line where a compensator is fitted, system stability is improved since the compensation creates a virtual infinite busbar over the range of currents for which it is designed.

A further feature of the control system of the present invention is that the microprocessor may be linked to a remote data processor to permit override of the control signal as well as telemetry.

CLAIMS

1. A controller for an alternating current power supply for a variable load comprising voltage sampling means connectable to a power supply to sample the voltage applied to said load, at least one linear reactor connectable to said power supply and controller means connected between said reactor and said sampling means, said controller means being adapted to connect said reactor to said power supply for a substantially integral number of half-cycles of the supply voltage, shunt capacitors also being connected between said controller means and said sampling means.

2. A controller for an alternating current power supply as claimed in claim 1 wherein said linear reactor comprises a plurality of windings each having associated series switching means to permit the respective winding to be connected across said power supply.

3. A controller for an alternating current power supply as claimed in claim 1 wherein said linear reactor comprises a plurality of component windings each having associated series and shunt switching means selectively to connect said component windings in series combination across said alternating current power supply.

4. A controller for an alternating current power supply as claimed in claim 3 having four separate component windings.

5. A controller for an alternating current power supply as claimed in claim 5 wherein said windings respectively include 36%, 28% 25% and 11% of the total combined number of windings.

6. A controller for an alternating current power supply substantially as herein described with reference to and as shown in the accompanying drawings.

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